Item ID Number	00270
Author	
Corporate Author	The Dow Chemical Company, Midland Michigan
Report/Article Title	TORDON Herbicide for Defoliation
Journal/Book Title	
Year	1965
Month/Day	August 18
Color	☐
Number of Images	38
Description Notes	Includes color photographs

THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

TORDON Herbicide
For
Defoliation

August 18, 1965

TABLE OF CONTENTS

INTRODUCTION

At the Annual Defoliation Conference, August 10-11, 1965 at the U. S. Army Biological Laboratories, Ft. Detrick, Fredrick, Maryland, it was evident that the commercial Dow herbicide, TORDON, is one of the most successful defoliants and brush control herbicides presently available. A great many tests in commercial and military programs from laboratory-scale to large-area field operations have revealed the superior performance of TORDON in defoliation, brush control and deforestation.

Following the Defoliation Conference, a technical presentation was made to the Department of Defense, Research and Engineering. At this meeting, it was suggested that a large-scale field test application of TORDON was in order. The operations in Viet Nam have shown that herbicidal spray applications are feasible and we feel that they are operationally sound. It seems reasonable to consider the massive use of defoliation and deforestation as an integral part of field operations.

We feel that the necessary capabilities are at hand to satisfy these needs and that Dow is in an excellent position to assist in this effort.

OBJECTIVE

The purpose of this brochure is to present various experiences with the new Dow commercial herbicide, TORDON, emphasizing its superior performance in domestic and military test programs.

Along with it, we offer the technical services of The Dow Chemical Company in support of the use of TORDON by the Department of Defense, and we seek any advice which will enable us to better plan to meet future needs for TORDON and any other associated herbicides.

TECHNICAL SUMMARY

A new herbicide, 4-amino-3,5,6-trichloropicolinic acid, has been discovered and developed by The Dow Chemical Company. Formulations containing this herbicide are known by the Dow trade name TORDON.

TORDON herbicide is safe to man and animals as determined by numerous experiments. The herbicidal activity of this new herbicide results from both leaf and root absorption. TORDON is rapidly translocated throughout plant parts, and the compound remains herbicidally active in soil for extended periods.

TORDON herbicide is effective at low concentrations on broad-leaved plants including most woody plants and vines and when combined with 2,4-D, it controls an extremely broad spectrum of woody plants. TORDON is more consistent in performance in the field under varying moisture and growth conditions than 2,4-D and 2,4,5-T.

Aerial applications of sprays and pellet formulations of TORDON herbicide appear feasible for military use on broad areas. Hand applications of pellets on limited areas can provide control of brush in many areas. Combination with other Dow herbicides can provide control of most vegetation including grasses. We believe TORDON herbicide can be useful in several military situations and the technical information and commercial experience now available are sufficient to justify its use in Southeast Asia now.

TECHNICAL DISCUSSION

TORDON herbicide represents a new class of herbicides which are more active than other presently known herbicides. This is Figure 1 the molecular structure of TORDON herbicide which chemically is known as 4-amino-3,5,6-trichloropicolinic acid. TORDON herbicide was discovered, after extensive synthesis and analytical work, as a result of observations of growth malformations on plants. These experiments were being run by Dow to discover a chemical to conserve nitrogen in soil.

TORDON can be made into water soluble formulations and can be mixed with other water soluble herbicides. Dow's formulation laboratories have developed excellent formulations of TORDON containing 2,4-D and 2,4,5-T.

TORDON is a relatively safe compound to use. For instance, in our toxicity studies, the LD 50 in white rats is 8200 milligrams per kilogram of body weight. In comparison, 2,4-D has an LD 50 in white rats of about 450 milligrams per kilogram of body weight. Toxicological studies have also been conducted with TORDON herbicide to determine its effect from application to the skin, in the eye, and through vapor inhalation. No apparent problems were observed in these experiments at the dosage levels used. Sub-acute toxicity studies have been conducted on rats, sheep, beef cattle, Japanese quail, and chickens. The results of these studies show that TORDON is a relatively safe compound in the diet of these animals. Extensive studies have been conducted on aquatic animals such as snails, daphnia, gold fish, guppies, trout, sun fish, fat head minnow and bullheads. Most fish can tolerate concentrations of about 100 parts per million in water without fish-kill occurring. These studies have shown that sub-lethal concentrations of TORDON in aquatic systems caused no build-up in their tissue which would affect the aquatic organism itself or the animal consuming it in the food chain cycle.

Human subjects have been exposed to 5 and 10% water solutions of TORDON for extended periods of time and no skin irritation or skin sensitization has been found attributable to this exposure.

Two-year feeding studies have been completed in albino rats and beagle dogs at concentrations of 15, 50 and 150 milligrams per kilogram of body weight. At the end of this study no adverse effects were observed in any of the test animals. Preliminary tissue analyses have been made on animals that have been fed high levels of TORDON. The results of these studies show that TORDON was rapidly excreted from the animal primarily in the feces and urine and does not appear to concentrate in animal fat, muscle and nerve tissue. It is concluded from these studies that TORDON herbicide will not create any hazard to livestock, wildlife including aquatic organisms, or man when used at rates necessary for vegetation control or manipulation.

TORDON is not rapidly decomposed in soil and remains herbicidally active for extended periods of time in most soils. This picture shows a persistence study in one of our laboratories where the chemical was mixed in the soil and sensitive plants were planted periodically. This system eliminates the leaching factor in the determination of loss of a herbicide from soil. Nineteen months after the application of TORDON, plants were still being controlled at the rates used in this experiment. In field studies TORDON at the rate of 2 to 3 pounds per acre have killed sensitive plants in most soils one year after application and in some soils for as long as two years after application. Under most situations TORDON has disappeared from the soil three years after treatment using these rates. TORDON is adsorbed on some clays and on organic matter. The clay and organic matter content of soil directly influence the longevity of TORDON under field conditions. On a highly leachable sandy or gravely soil or on high rainfall sites TORDON herbicide may be removed from the soil

Figure 2

in 6 to 9 months. In comparison, 2,4-D and 2,4,5-T are fairly rapidly decomposed in soil and normally do not remain active in soil for more than 2 or 3 weeks.

TORDON herbicide is absorbed both through roots and leaves of plants and is an extremely active compound for the control of broad-leaved plants at concentrations much lower than other commercial herbicides. 2,4-D and 2,4,5-T were among the most active organic herbicides prior to the discovery of TORDON. Direct comparisons between TORDON, 2,4-D and 2,4,5-T have been made in many of our experiments. This next picture shows Figure 3 a comparison of TORDON herbicide and 2,4-D using field beans as the test plant. Applications were made to the soil thus root absorption was the primary route of entry into the plant. TORDON herbicide at 1/4 ounce per acre was considerably more effective than 8 times that rate of 2,4-D. Although 2,4-D can be absorbed by the plant roots it is much less active by this route than through applications to the leaf. TORDON appears to be at least as active by root absorption as from leaf absorption. The next picture shows the comparative effectiveness of TORDON, Figure 4 2,4-D and 2,4,5-T by leaf absorption. TORDON at 5 parts per million in a water solution resulted in more epinasty on the terminal portion of the plant on cucumbers than 2,4-D at 300 parts per million or 2,4,5-T at 5 parts per million. TORDON is very rapidly absorbed through leaves of plants and is translocated rapidly throughout the aerial and root portion of the plant within minutes after application.

These factors are important in the field performance of TORDON. Since it can be absorbed by both leaves and roots to kill plants, environmental conditions do not effect the herbicidal activity to as great an extent as with most other herbicides. Thus, applications can be applied under less than ideal conditions and satisfactory results can be anticipated. This can be extremely

helpful in scheduling applications and providing longer periods of time for spraying.

As mentioned earlier, TORDON is most active on broad-leaved plants. The picture in Figure 5 shows the control of tomatoes, beans, cucumbers and soybeans with TORDON at 4 ounces per acre of TORDON while the grasses (wheat and corn) survived this application. Figure 5

The first TORDON sample outside of The Dow Chemical Company was provided to the Crops Division at Fort Detrick for their use in November 1962. Dr. Minarik was briefed on the results we had obtained to date on this compound and small samples were made available for laboratory evaluations. Experiments were conducted by Dow on the use of TORDON herbicide for anti-crop application for Fort Detrick on a research contract. We collaborated with Dr. Minarik and his associates by making available some of our plot areas for evaluation during 1962 and 1963. Some of these plots are shown in pictures taken near Chattanooga, Tennessee. These applications were made on July 17, 1962 and observations were made the fall of that year about three months following treatment. The first picture shows an application made with TORDON at 1 pound per 100 gallons of spray solution applied to wet the plant foliage. Note that there is no regrowth or stem resprouting on any of these species. Figure 6 The next picture shows an area treated with 2,4,5-T at 4 pounds per 100 gallons, the best commercial treatment, as a comparison. Note the regrowth from the stem and from the root area of these species. Figure 7 This work was conducted in co-operation with the Tennessee Valley Authority.

Another experimental site was located in South Georgia. The picture in Figure 8 shows an area at time of treatment compared with the results from a treatment of TORDON at 1 pound per 100 gallons. Figure 8 The next picture was taken three growing seasons after application and shows the high degree of control Figure 9

that can be obtained with this herbicide, with no resprouting or reseeding back into the treated area. Similar experimental areas were established and evaluated in eight different locations in the United States and other tests were established in the Caribbean area and in England. One comparison in these experiments was the use of 2,4-D and 2,4,5-T as additives to TORDON. The data in Figure 10 shows the results obtained when TORDON plus 2,4-D was compared with TORDON plus 2,4,5-T in foliage sprays. These ratings were made two years after application and they show that 2,4-D was as effective as 2,4,5-T on almost all of the species in the experimental areas. 2,4-D was selected as the combination herbicide to formulate with TORDON for commercial woody plant control. Figure 10

The table in Figure 11 shows comparative data between the use of TORDON 101 Mixture (containing TORDON and 2,4-D) and a commercial 2,4,5-T ester formulation. TORDON 101 Mixture contains 1/2 pound of TORDON and 2 pounds of 2,4-D per gallon. The results two growing seasons following treatment indicate the higher degree of efficacy of the TORDON 101 Mixture in controlling most woody plants. 2,4,5-T normally gives good top kill of most woody plants, but regrowth from the root collar or from the roots often becomes a problem the same season of treatment and certainly by the end of the second growing season. In these treatments, it was obvious that TORDON gave excellent control of regrowth from both the root collar sprouting and root suckering species as well as providing good top kill following application. Leaf kill normally occurs within 10 to 14 days after application, but this depends somewhat on conditions prevailing during and following application. TORDON 101 Mixture has been tested through the world for woody plant control. Figure 11

The picture in Figure 12 is the result of applications on a power line in Australia where 2 gallons per acre were applied a year prior to this picture. Figure 12

The next two pictures show before and after treatment results near Bogota, Colombia where aerial application of TORDON 101 Mixture at 1 gallon per acre was used. Figure 13 Figure 14

In Mexico, TORDON 101 Mixture has also performed satisfactorily for woody plant control, as evidenced in Figure 15. Figure 15

Samples of TORDON 101 Mixture and other TORDON formulations were given to Dr. Minarik at Fort Detrick during 1963 and 1964. We understand excellent control of several species has been obtained in experimental applications that have been made by the Crops Division at several locations in the United States and in Southeast Asia.

An extensive amount of research has been conducted by Dow in developing TORDON 101 Mixture for brush control on utility lines in the United States using high volume ground sprayers, fixed nozzles, mistblowers, and aerial application equipment.

The picture in Figure 16 shows an area being treated in a swamp area north of New Orleans, Louisiana. TORDON 101 Mixture at 3 gallons per acre was applied in this application and the control obtained 4 months after spraying the area is shown in Figure 17. Aerial applications have been used commercially for the past 2 years in the United States, Canada, Mexico, Colombia, Australia, and several other areas. Figure 16 Figure 17

A 160-acre block was treated at Johnson City, Texas using TORDON applied by fixed-wing aircraft. Figure 18 is a picture of this area when treated. White brush has been a problem species, and 2,4-D and 2,4,5-T have not given adequate control of this brush species which is a serious problem on several million acrea of Texas ranch land. The next picture shows the results about 2 months after application. Figure 18 Figure 19

TORDON 101 Mixture has been rapidly accepted for the control of woody plants through the United States and Canada (and in several other countries) in preference to other materials available for this use such as 2,4-D and 2,4,5-T. In this third year of sales of TORDON 101 Mixture approximately 15 to 20% of the woody plant control operations in the United States and Canada are using TORDON 101 Mixture. For instance, at Camp Gagetown, the largest military installation in Canada, 4,500 acres of brush has been sprayed by aerial equipment using TORDON 101 Mixture. From both the experimental work that has been conducted and the commercial acceptance of this product in practice, it is evident that TORDON 101 Mixture is a superior brush killing product.

As mentioned earlier, TORDON is rapidly absorbed by roots of plants. Early in the development of this product granular and pelleted formulations were made to explore the possible use of this product for woody plant control with soil applications. This project has proved very successful and a pelleted product has been developed. Applications of this product at the rate of 6 to 8 pounds of TORDON per acre have given a high degree of control of most woody plants when applied during periods of active plant growth. TORDON pellets can easily be applied by hand by workmen with no special training. Applications are made over the root area of woody plants which are normally killed within a relatively short time after application if moisture is available. TORDON pellets have proved useful for spot applications to brush areas which are difficult to reach with equipment or where hand labor is readily available. TORDON pellets should be useful for controlling brush in areas around military installations or outposts to eliminate cover. Figure 20

Figure 21 shows the results of applications of TORDON pellets in the United States three months following treatment. Figure 21

Figure 22 shows the results in Mexico a year following Figure 22

application. TORDON pellets have been applied by aerial equipment in several areas of the world. Figure 23 shows an application in Oregon. Figure 24 is a picture of results in Oregon.

Figure 23

Figure 24

TORDON herbicide has also been very effective for the control of vines which are common problems in jungles throughout the world. Because of the increased effectiveness in the control of both woody plants themselves and the woody vines in these areas, visibility is increased considerably with the use of TORDON formulations compared with other methods. To provide complete vegetation control, including grasses, TORDON can be used in combination with other Dow herbicides. Results obtained by Dr. Minarik and his associates in Southeast Asia, coupled with Dow experience in commercial research, development and commercial use of these products, should be very helpful in solving vegetation control problems which the Defense Department faces in its operation and maintenance of field activities and installations. Since TORDON is such an effective new tool for manipulation of vegetation, we believe that it has a real place to serve in Southeast Asia and can provide long-term control of vegetation without injuring animals or people. Formulations are available that can be applied in equipment which is operational now, and we feel that the application of TORDON 101 Mixture would be of military significance in Viet Nam now. It can be used to kill trees and brush around key installations thus materially assisting in their defense. It can be used to create barrier strips or to isolate zones of activity and would restrict the movement of the Viet Cong by increasing observational capabilities. We believe that the use of TORDON 101 Mixture in strategic areas would help reduce United States and Viet Nam casualties.

CONCLUSIONS

1. A new herbicide, TORDON 101 Mixture, is a superior defoliant and brush control chemical.

2. Six years of Dow research and three years of research by the U. S. Army Biological Laboratories at Fort Detrick have reported outstanding success for TORDON in comparison with all other available commercial herbicides.

3. TORDON has a very low toxicity and is much less toxic than any other defoliant now being used.

4. High analysis pelleted TORDON formulations are available for either air application or for ground applications to clear areas around military bases.

5. TORDON 101 Mixture is commercially available today, and can be applied in equipment which is operational now.

6. The application of TORDON 101 Mixture would be of military significance in Viet Nam now because it would

   a. Assist in the defense of key installations

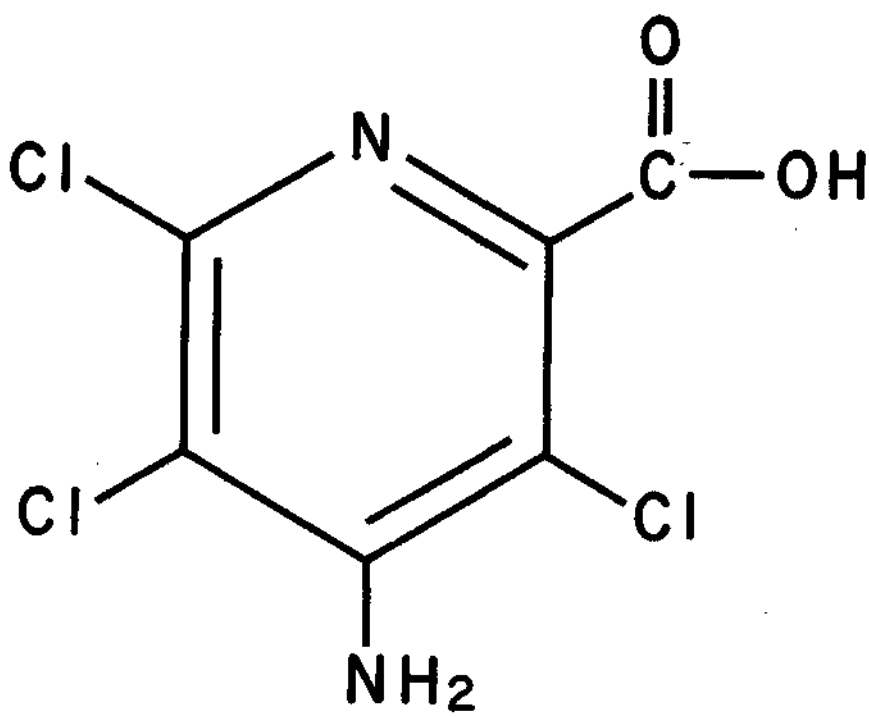
   b. Restrict the movement of the Viet Cong

   c. Increase observational capabilities

   d. Help reduce United States and Viet Nam casualties

Figure 1

TORDON® HERBICIDE



4-amino-3,5,6-trichloropicolinic acid

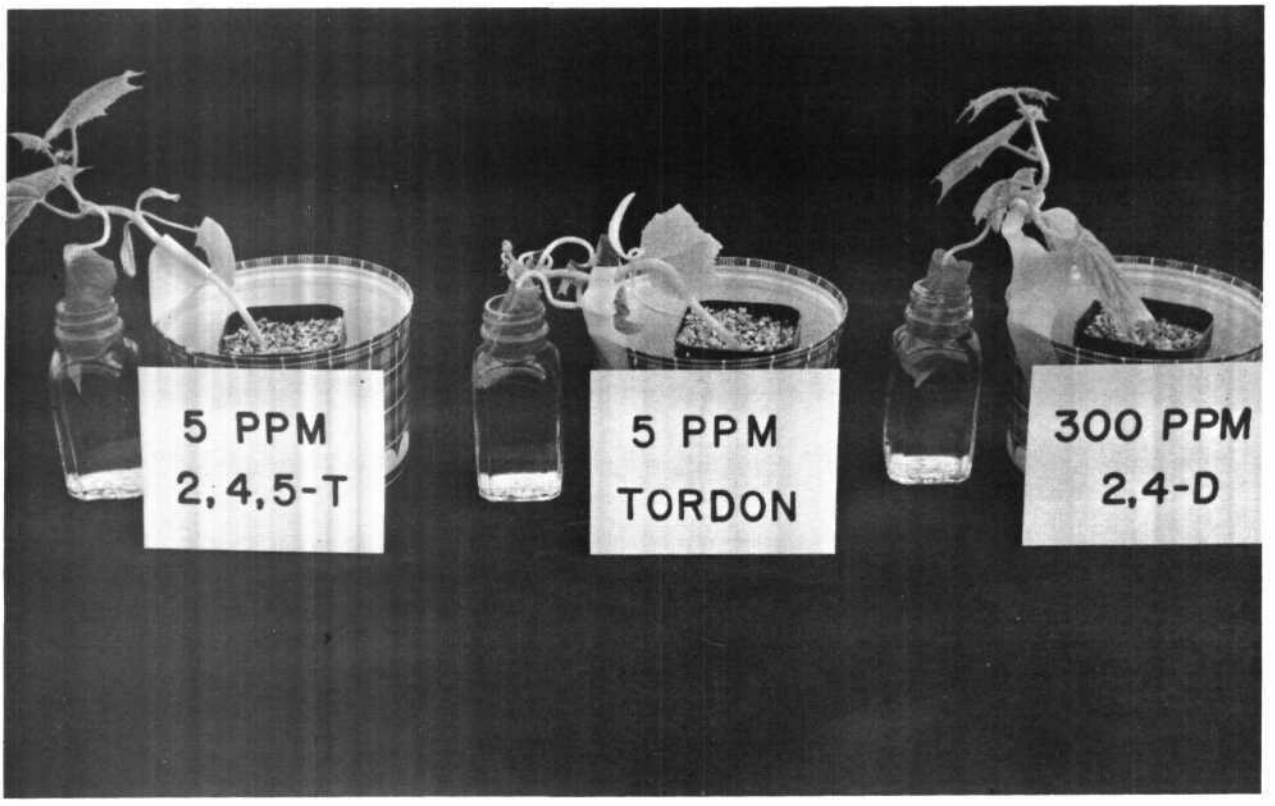
Figure 2

A persistence test with Tordon herbicide

Figure 3

Soil application of Tordon and 2,4-D on field beans

Figure 4



Leaf absorption of Tordon herbicide compared with 2,4-D and 2,4,5-T, using cucumbers

Figure 5

Selectivity of Tordon herbicide

Figure 6

Response of brush at Chattanooga, Tennessee,
to Tordon 101 Mixture

Figure 7

Response of brush at Chattanooga, Tennessee,
to 2,4,5-T

Figure 8

An area near Thomasville, Georgia,
at time of application

Figure 9

The Thomasville, Georgia, area 3 growing seasons after application of Tordon 101 Mixture

Figure 10

PER CENT TOP KILL WITH NO RESPROUTING OF SEVERAL BRUSH SPECIES TWO GROWING SEASONS AFTER APPLICATION

WOODY PLANTS	Tordon + 2,4-D	Tordon + 2,4,5-T
	Per Cent	Per Cent
Maple (*Acer* spp.)	91	86
Ash (*Fraxinus* spp.)	41	25
Balsam-Fir (*Abies balsamea*)	83	80
Aspen (*Populus* spp.)	100	100
Birch (*Betula papyrifera*)	100	100
Alder (*Alnus rugosa*)	100	100
Cherry (*Prunus* spp.)	100	100
Sweet Gum (*Liquidambar Styraciflua*)	76	93
Oak (*Quercus* spp.)	66	40
Pine (*Pinus* spp.)	74	70

Figure 11

PER CENT TOP KILL WITH NO RESPROUTING OF SEVERAL BRUSH SPECIES TWO GROWING SEASONS AFTER APPLICATION

WOODY PLANTS	Tordon 101 Mixture	2,4,5-T Ester
	Per Cent	Per Cent
Coniferous species	99	14
Aspen (*Populus* spp.)	100	90
Maple (*Acer* spp.)	100	33
Oak (*Quercus* spp.)	84	34
Ash (*Fraxinus* spp.)	62	66
Sweet Gum (Liquidambar Styraciflua)	80	59
Sassafras (*Sassafras albidum*)	91	42
Cypress (*Taxodium* spp.)	100	42
Buttonbush (*Cephalanthus pubescens*)	100	80
Cherry (Prunus spp.)	100	80
Hickory (*Carya* spp.)	45	8
Persimmon (*Diospyros* spp.)	100	58
Black Locust (*Robinia Psudo-Acacia*)	99	49
Black Gum (*Nyssa sylvatica*)	100	13

Figure 12

Results from application of Tordon 101 Mixture
at 2 gallons per acre 1 year following treatment
Sidney, Australia

Figure 13

An untreated area near Bogota, Colombia

Figure 14

An area near Bogota, Colombia, 1 year after treatment with tordon 101 Mixture

Figure 15

An area in Mexico 1 year after treatment
with Tordon 101 Mixture

Figure 16

Aerial application of Tordon 101 Mixture
at 3 gallons per acre in a swamp near
New Orleans, Louisiana

Figure 17

The area near New Orleans 5 months
after treatment

Figure 18

White brush near Johnson City, Texas,
at time of treatment

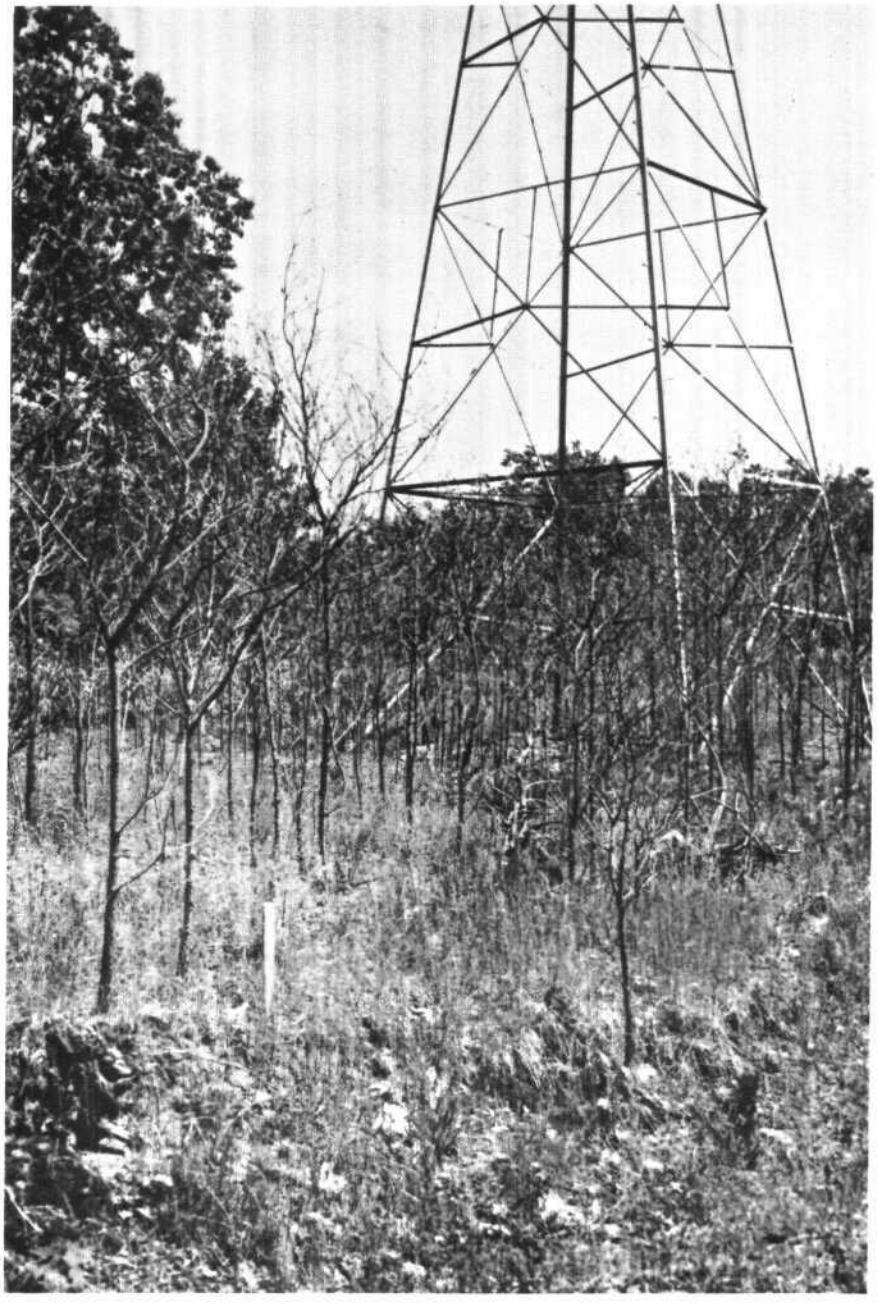
Figure 19

White brush at Johnson City, Texas,
2 months after application of Tordon

Figure 20

Spreading Tordon pellets by hand over
the root system of brush in Michigan

Figure 21

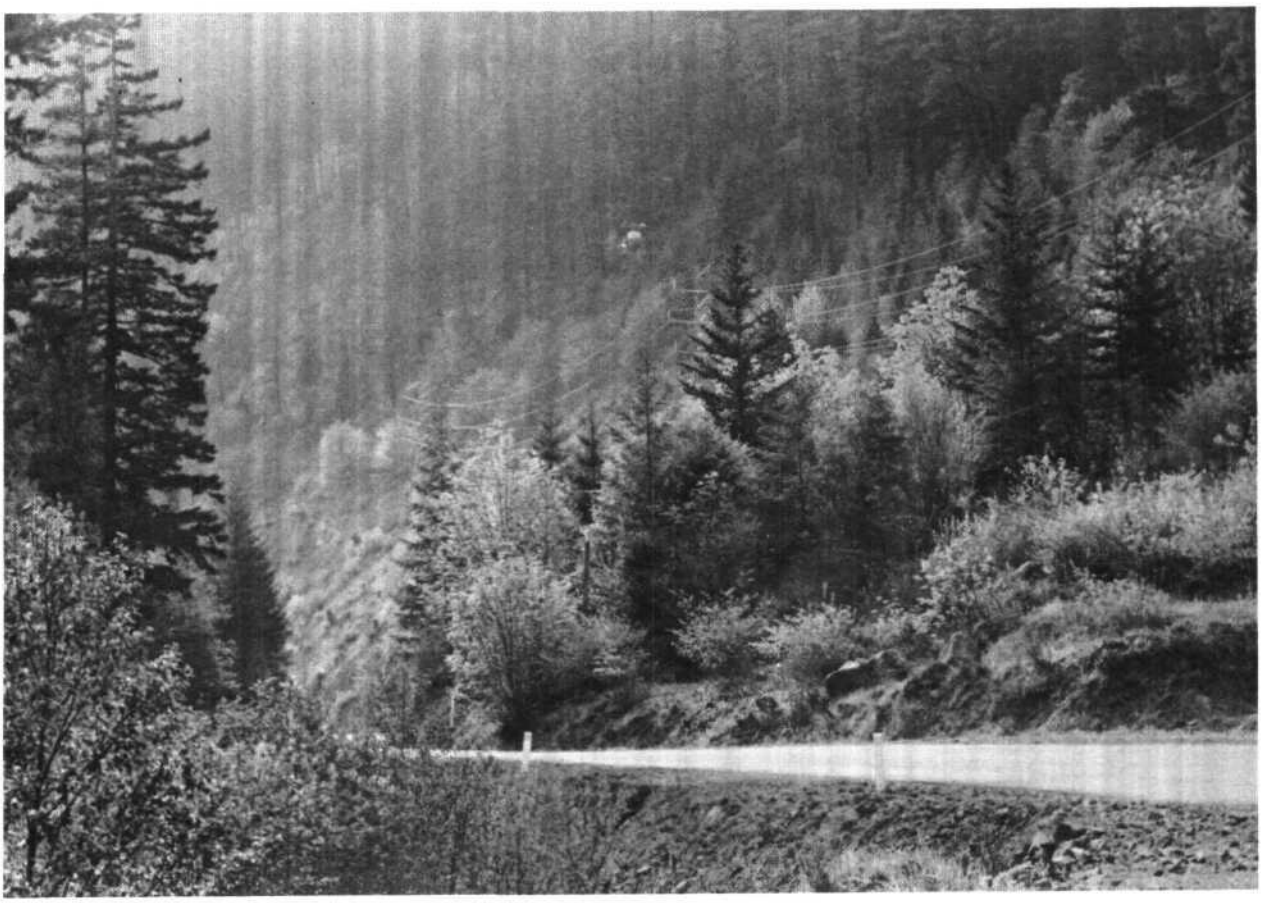


Brush in Michigan 3 months after
application of Tordon pellets

Figure 22

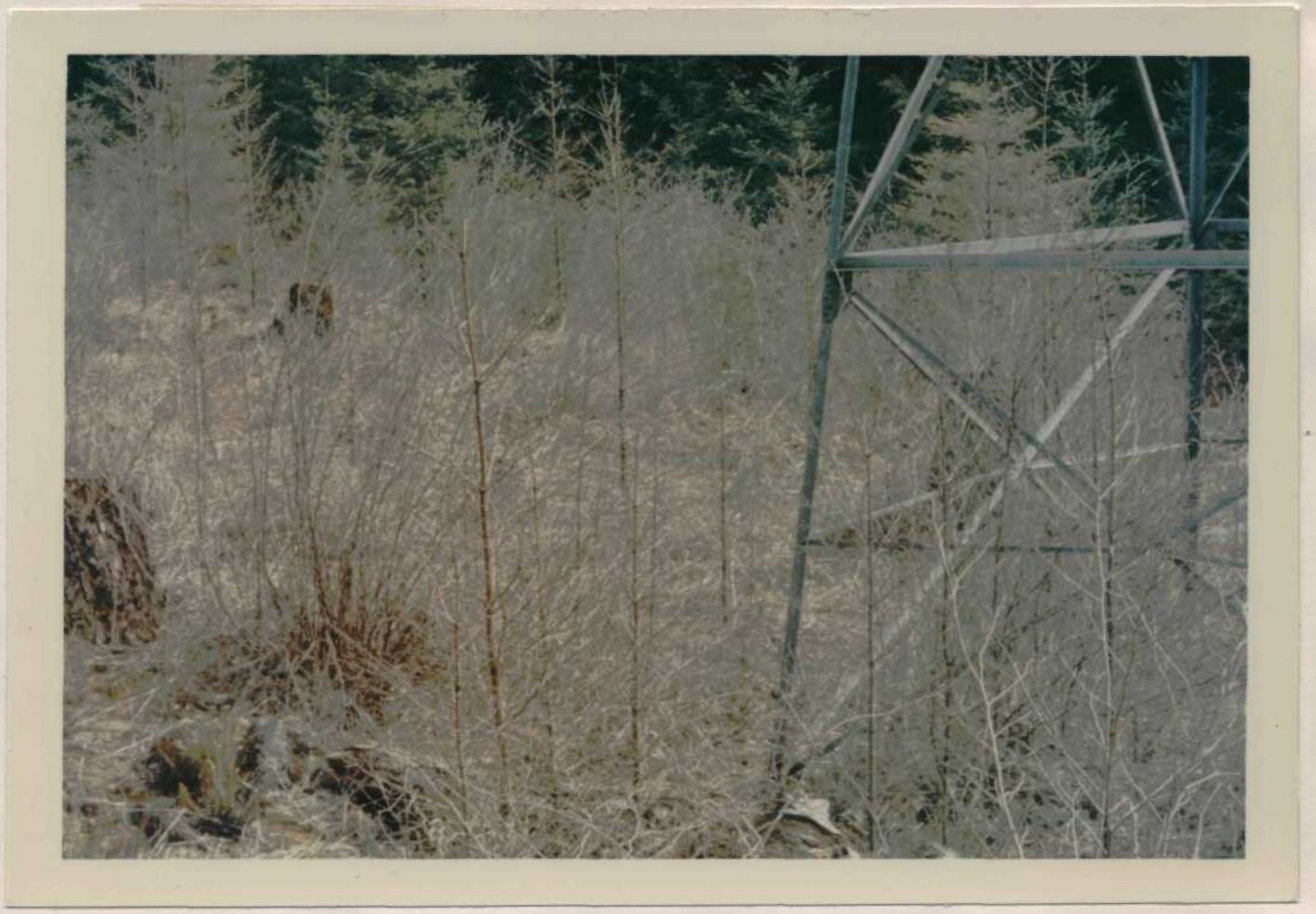
Brush control in Mexico with Tordon pellets
1 year after treatment

Figure 23



Aerial application of Tordon pellets
in Oregon

Figure 24



Brush control in Oregon 1 year after
aerial application of Tordon pellets